O 56: [DS] Progress in Micro- and Nanopatterning: Techniques and Applications III (Focused Session, jointly with O - Organisers: Graaf, Hartmann)

Time: Wednesday 15:00–17:00 Location: GER 38

O 56.1 Wed 15:00 GER 38

Femtosecond laser induced recrystallization and ablation of hydrogenated amorphous silicon films — •Babak Soleymanzadeh[1], Christian Strüber[1], Helmut Stiebig[1,2], and Walter Pfeiffer[1] — [1]Universität Bielefeld, Universitätsstr. 25, 33615 Bielefeld, Germany — [2]Malibu GmbH & Co. KG, Böttcher Str. 7, 33609 Bielefeld, Germany

Ultrashort laser pulses offer new and fascinating possibilities in the field of laser material processing. Here we investigate the femtosecond laser induced recrystallization and ablation of hydrogenated amorphous silicon films (300 nm thickness) grown on glass substrates by large area (>1 m^2) plasma-enhanced chemical-vapor deposition. At laser fluences of <40 $mJcm^{-2}$ (800 nm, <100 fs pulse duration) recrystallization of the amorphous silicon layer is observed in spatially resolved Raman micro-spectroscopy. The fluence dependence of this recrystallization indicates that a nonlinear excitation mechanism is responsible. At slightly higher fluences the amorphous silicon thin-film is ablated. Scanning electron microscopy and energy-dispersive X-ray spectroscopy (EDX) is applied to investigate the ablation process for various laser fluences. The prospect of using femtosecond laser induced material processing in silicon thin-film photovoltaics is discussed.

O 56.2 Wed 15:15 GER 38

Photothermal Laser Micro- and Nanoprocessing of Mesoporous Gold — •Lina Schade[1], Mareike Mathieu[1,2], Monika Biener[2], Juergen Biener[2], and Nils Hartmann[1] — [1]Fakultät für Chemie, NETZ, CeNIDE, Universität Duisburg-Essen, Universitätsstr. 5, 45141 Essen, Germany — [2]LLNL, Livermore, CA 94550, USA

In recent years, mesoporous gold has gained significant attention as a novel material in actuation, sensing and catalysis. The particular properties of this material result from its spongelike open-cell morphology with pore sizes of about 25 nm. Techniques which allow one to engineer mesoporous gold on a micro- and nanoscale, of course, are of high interest in view of fundamental studies and technical applications. Common annealing procedures, for example, provide a means to adjust the pore size in the range of 50 - 600 nm and investigate size dependent properties, such as the enhancement effect in surface enhanced Raman spectroscopy (SERS) [1]. Here we report on a photothermal laser technique for micro- and nanoprocessing of mesoporous gold [2]. A focused beam of a cw-laser with a wavelength of 532 nm and a 1/e spot size of 1.4 microns is used to locally anneal the substrate surface and fine tune the pore structure. This allows one to fabricate porous gradients on micrometer length scales. In addition, thiol-based self-assembled monolayers provide unique opportunities to functionalize these porous structures [2]. Prospects in SERS measurements and other applications are discussed.

[1] S.O Kucheyev, et al., Appl. Phys. Lett. 89 (2006) 053102.
[2] M. Mathieu, N. Hartmann, NJP, in press.

O 56.3 Wed 15:30 GER 38

Photothermal laser patterning of buried polymer interfaces — •Anja Schröter, Steffen Franzka, and Nils Hartmann — Fakultät für Chemie, CeNIDE and NETZ, Universität Duisburg-Essen, Universitätsstr. 5, 45141 Essen, Germany

Covalent attachment of polymer films provides a versatile means to taylor chemical and physical surface properties. Alternative to the approach of growing a polymer on a surface [1], here we report on a facile and flexible photothermal procedure for local grafting of thin polymer films to solid surfaces. Surface-oxidized silicon samples are coated with alkylsiloxane monolayers. After wet-chemical treatment in order to form azide-terminated monolayers a thin polymer film is spin-coated on top of the monolayer. Local irradiation with a focused beam of a diode-pumped solid-state laser at a wavelength of 532 nm thermally activates the azide groups at the buried polymer interface and leads to local covalent attachment of the polymer. Subsequently, polymer material, which is not coupled to the surface, is removed via sonication. The influence of incident laser power and irradiation time is investigated. At a 1/e focal spot diameter of 2.1 microns dots with diameters close to 1 micron can be fabricated. This procedure allows for rapid large-scale patterned attachment of a wide spectrum of polymers.

[1] M. Mathieu, A. Friebe, S. Franzka, M. Ulbricht, N. Hartmann, Langmuir 25 (2009) 12393.

O 56.4 Wed 15:45 GER 38

Photothermally induced chemical patterning of organic monolayers on oxide-free silicon substrates — •Martin Przyklenk[1], Benjamin Klingebiel[1], Luc Scheres[2], Han Zuilhof[2], and Nils Hartmann[1] — [1]Fakultät für Chemie, CeNIDE, NETZ, Universität Duisburg-Essen, Universitätsstr. 5, 45141 Essen — [2]Laboratory of Organic Chemistry, Wageningen University, Dreijenplein 8, 6703 HB Wageningen, The Netherlands

Patterned self-assembeld organic monolayers (SAMs) are widely used as templates to build up complex functional surface structures. A simple routine for nanopattering of organic monolayers down to 100 nm and below relies on photothermal processes [1,2]. In photothermal processing a focused laser beam is used to locally heat the substrate and initiate thermal decomposition of the monolayer. Here we use a simple photothermal procedure for direct chemical functionalization of organic monolayers [1]. Oxide-free silicon samples are coated with alkyl and alkenyl monolayers [2]. Through irradiation with a focused beam of an argon ion laser at a wavelength of 514 nm in gaseous bromine local bromination of the monolayer takes place. Mechanistic aspects and prospects of photothermal routines in micro- and nanofabrication of multifunctional organic monolayers are discussed.

[1] B. Klingebiel, A. Schröter, S. Franzka, N. Hartmann, ChemPhysChem 10 (2009) 2000.
[2] L. Scheres, B. Klingebiel, J. ter Maat, M. Giesbers, H. de Jong, N. Hartmann, H. Zuilhof, Small 6 (2010) 1918.

O 56.5 Wed 16:00 GER 38

Pattern transfer on large samples using a sub-aperture reactive ion beam — •André Miessler, Agnes Mill, Jürgen W. Gerlach, and Thomas Arnold — Leibniz-Institut für Oberflächenmodifizierung (IOM), Permoserstrasse 15, D-04318 Leipzig, Germany

In comparison to sole Ar ion beam sputtering Reactive Ion Beam Etching (RIBE) reveals the main advantage of increasing the selectivity for different kind of materials due to chemical contributions during the material removal. Therefore RIBE is qualified to be an excellent candidate for pattern transfer applications. The goal of the present study is to apply a sub-aperture reactive ion beam for pattern transfer on large fused silica samples. Concerning this matter, the etching behavior in the ion beam periphery plays a decisive role.

Using CF_4 as reactive gas, XPS measurements of the modified surface exposes impurities like Ni, Fe and Cr, which belongs to chemically eroded material of the plasma pot as well as an accumulation of carbon (up to 40 atomic percent) in the beam periphery, respectively. The substitution of CF_4 by NF_3 as reactive gas reveals a lot of benefits: more stable ion beam conditions in combination with a reduction of the beam size down to a diameter of 5 mm and a reduced amount of the Ni, Fe and Cr contaminations. However, a layer formation of silicon nitride handicaps the chemical contribution of the etching process. These negative side effects influence the transfer of trench structures on quartz by changing the selectivity due to altered chemical reaction of the modified resist layer. Concerning this we investigate the pattern transfer on large fused silica plates using NF_3-sub-aperture RIBE.

O 56.6 Wed 16:15 GER 38

Swift Heavy Ion Beam Shaping Of Sub-Micron Structures — •R. Ferhati[1], N. Guilliard[1], T. Weishaar[1], S. Amirthapandian[1], M. Fritschke[2], L. Bischoff[2], and W. Bolse[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart — [2]Forschungszentrum Dresden

Already in 1983 it was discovered, that swift heavy ion (SHI) irradiation of metallic glasses results in anisotropic deformation (shrinking along the beam direction expansion in perpendicular directions) [1]. We have employed this "hammering effect" to reshape sub-micrometer structures by SHI bombardment under proper variation of the beam incidence angle. Utilizing the focused ion beam (FIB) technique, a rectangular grid with varying lateral distances of 100 to 5000 nm was cut into a 100 nm thick NiO- resp. ZnO-film from their surfaces down to the oxidized Si-substrate, in order to produce small oxide "ashlars".

The samples were then irradiated under grazing incidence and continuous azimuthal target rotation with 1.4 GeV U- (NiO) and 0.95 GeV Au-ions (ZnO), respectively, in our new in-situ SEM at the UNILAC accelerator of GSI [2]. After certain fluence steps, the irradiation was stopped and one and the same spot was analyzed by means of SEM in order to investigate the evolution of the irradiated objects. Depending on their initial size complex structures (egg-, cone-, pillar-, forceps-, tooth-like) were formed, which can only be understood if besides the hammering effect deformation due to surface tension and yield stress are taken into account. [1] S. Klaumünzer, G. Schumacher, Phys. Rev. Lett. 51 (1983), [2] S. Amirthapandian, et al., Rev.Sci.Instr. 81, (2010)

O 56.7 Wed 16:30 GER 38

Surfactant driven self-organized surface patterns by ion beam erosion — •Hans Hofsäss and Kun Zhang — II. Physikalisches Institut, Universität Göttingen, 37077 Göttingen, Germany

Self-organized pattern formation on surfaces by ion beam erosion and driven by metal surfactant atoms is discussed. Si substrates were irradiated with 5 keV Xe ions at normal incidence and ion fluences up to 5x10^{17} Xe^+/cm^2 under continuous deposition of surfactant atoms. In the absence of surfactants uniform flat surfaces are obtained. With surfactants pronounced patterns like dots, combinations of dots and ripples as well as ripples with about 100 nm wavelength are generated. The surfactant coverage and deposition direction determine the pattern type and the pattern orientation, respectively. A critical steady-state coverage for onset of dot formation and onset of ripple formation is between about 10^{15} and 5x10^{15} atoms/cm^2. With increasing ion fluence the pattern contrast increases but the pattern type remains unchanged. The surface region consists of a thin amorphous metal silicide layer with high metal concentration in the ripple and dot regions. Pattern formation is explained by ion induced diffusion and phase separation of the initially flat amorphous silicide layer and subsequent ion beam erosion with composition dependent sputter yield. Directed deposition of metal surfactant causes preferential deposition and shadowing and determines the final pattern orientation and morphology. First results on the dynamic behaviour of the ripples are presented.

O 56.8 Wed 16:45 GER 38

Dynamics of surfactant induced ripple patterns on Si generated by ion beam erosion — •Kun Zhang, Hans Hofsäss, Hans-Gregor Gehrke, and Oliver Göpfert — II.Physikalisches Institut, Universität Göttingen, 37077 Göttingen, Germany

Some metallic surfactants induce pronounced dot and ripple patterns on Si substrates during normal and near normal ion incidence sputter erosion. In the absence of metal co-deposition uniform flat surfaces are obtained. It is known that surface ripples generated by ion beam erosion at glancing ion incidence propagate across the surface. In this work we investigate the propagation of ripple patterns triggered by surfactant atoms and a possible correlation between ripple propagation and directed deposition of surfactant atoms. Si substrates were irradiated with 5 keV Xe ions at normal ion incidence under continuous deposition of Fe or Mo surfactant atoms. With surfactants pronounced patterns like dots, combinations of dots and ripples as well as ripples with about 100 nm wavelength and up to 12 nm in height are generated. The dynamics of patterns, in particular the propagation of ripples across the surface with increasing ion fluence was investigated using sequential ion irradiation and scanning electron microscopy analysis. Specific regions on the irradiated samples were identified using thin marker grooves prepared by focused ion beam milling. Using pattern recognition methods we are able to determine the fluence dependent shift of the ripple patterns with respect to the marker grooves. We find dynamic patterns with a propagation velocity of about 0.7 nm per 10^{15} ions/cm^2. A qualitative model for the ripple propagation is presented.